Irish Interdisciplinary Journal of Science & Research (IIJSR)
Volume 7, Issue 2, Pages 16-27, April-June 2023

Solar Powered Smart Irrigation Plant System Using Microcontroller

G. Keerthana*

PG Scholar, M.E-Communication Systems, E.G.S. Pillay Engineering College, Nagapattinam, Tamilnadu, India.
*Corresponding Author E-mail: gkeerthana2162000@gmail.com**

DOI: https://doi.org/10.46759/IIJSR.2023.7203

Article Received: 12 March 2023 *Article Accepted: 19 April 2023* *Article Published: 29 April 2023*

ABSTRACT

The design and the implementation of introducing smart irrigation technology enhances the effectiveness of water utilization and will help farmers make their activities more beneficial. it is to increase the agriculture sustainability in common and considering the characteristics of irrigation in the rural areas. This report brings forward new device based on wireless networks such as solar photovoltaic technology, Arduino-based controllers, transmitters, receivers, and sensor nodes are used to measure solar, soil moisture, humidity, temperature, and the sensor readings are transmitted to a remote station. Experimental results indicated that the developed system could provide a sustainable solution to enhance the efficiency of water use and to preserve it in the agricultural fields while using solar photovoltaic energy as a renewable power supply Encouraging the use of this energy-efficient system in various sectors creates a slowly declining cost to build-up the solar technology. Another sensor is implemented to measure the water tank level which serves as storage capacity that supplies the water to the system. With the integration of IoT, automated irrigation can be easily access and remotely monitored over the mobile application through a wireless communication device.

Keywords: Smart irrigation system; Solar photovoltaic; Arduino controller; Sensors.

1. Introduction

Basic necessities such as food and water have an integral part of everyday lives on Earth. Water plays a significant role in the environment. Globally, 70% of water comes from natural resources such as groundwater systems, lakes and rivers to support crop irrigations and feeding of livestock. The most abundant source of energy is the sun. Generating electricity from the solar energy through photovoltaic cells is being widely used nowadays. Encouraging the use of this energy-efficient system in various sectors creates a slowly declining cost to build-up the solar technology. This application can be used in irrigation system since it is a way producing clean energy for the environment. There are many applications of the solar generation system to consider such as irrigation system, livestock watering and domestic uses. Several approaches have been done by the researchers on how to improve the irrigation systems. With the global energy crisis, initiative for moving towards application of renewable resources carried out as possible solution [1]. Investing on zero-carbon emission and using energy efficient products.

2. Literature Survey

The Internet of Things (IoT) is increasingly being utilised to connect objects and collect data [2]. As a result, the Internet of Things' use in agriculture is crucial. The idea behind the project is to create a smart agriculture system that is connected to the internet of things. The technology is combined with an irrigation system to deal with Malaysia's variable weather. This system's microcontroller is a Raspberry Pi 4 Model B. The temperature and humidity in the surrounding region, as well as the moisture level of the soil, are monitored using the DHT22 and soil moisture sensor. The data will be available on both a smart phone and a computer. As a result, Internet of Things (IoT) and Raspberry Pi-based Smart Agriculture Systems have a significant impact on how farmers work. It will have a good impact on agricultural productivity as well. In Malaysia, employing IoT-based irrigation systems saves roughly 24.44 percent per year when compared to traditional irrigation systems. This would save money on

Irish Interdisciplinary Journal of Science & Research (IIJSR)
Volume 7, Issue 2, Pages 16-27, April-June 2023

labour expenditures while also preventing water waste in daily needs. Lots of works available in solar photovoltaic [3]-[7].

Arduino Microcontroller

The Arduino microcontroller is an easy to use yet powerful single board computer that has gained considerable traction in the hobby and professional market. The Arduino is open-source, which means hardware is reasonably priced and development software is free. This guide is for students in ME 2011, or students anywhere who are confronting the Arduino for the first time. For advanced Arduino users, prowl the web; there are lots of resources. The Arduino project was started in Italy to develop low cost hardware for interaction design. An overview is on the Wikipedia entry for Arduino. The Arduino home page is The Arduino hardware comes in several flavors [8].

In the United States, Sparkfun is a good source for Arduino hardware. This guide covers the Arduino Uno, a good choice for students and educators. With the Arduino board, you can write programs and create interface circuits to read switches and other sensors, and to control motors and lights with very little effort. Many of the pictures and drawings in this guide were taken from the documentation on the Arduino site, the place to turn if you need more information. The Arduino section on the ME 2011 web site, covers more on interfacing the Arduino to the real world [9].

ATMEL ATMEGA328

The Atmel ATmega328 microcontroller operating at 5 V with 2 Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters. The clock speed is 16 MHz, which translates to about executing about 300,000 lines of C source code per second. The board has 14 digital I/O pins and 6 analog input pins. There is a USB connector for talking to the host computer and a DC power jack for connecting an external 6-20 V power source, for example a 9 V battery, when running a program while not connected to the host computer. Headers are provided for interfacing to the I/O pins using 22 g solid wire or header connectors.

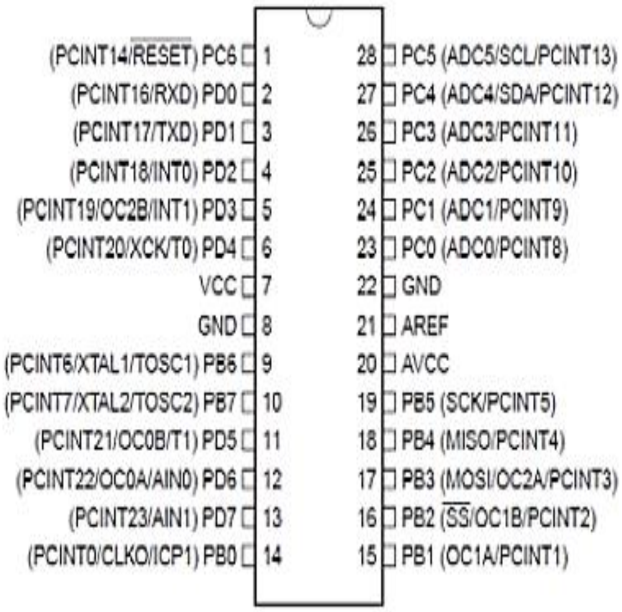


Figure 1. Pin Diagram

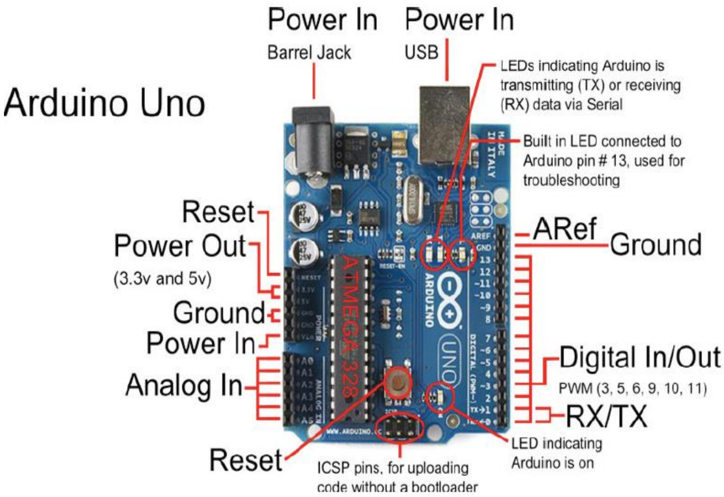


Figure 2. ATMEGA328 Diagram

An electronic signal transmitted as binary code that can be either the presence or absence of current, high and low voltages or short pulses at a particular frequency. Humans perceive the world in analog, but robots, computers and circuits use Digital. A digital signal is a signal that has only two states. The PWM worksheets or S.I.K circuit 12 Analog - A continuous stream of information with values between and including 0% and 100%. Humans perceive the world in analog. Everything we see and hear is a continuous transmission of information to our senses. The temperatures we perceive are never 100% hot or 100% cold, they are constantly changing between our ranges of acceptable temperatures.

DDRAM

Display data RAM (DDRAM) stores display data represented in 8-bit character codes. Its extended capacity is 80 X 8 bits, or 80 characters. The area in display data RAM (DDRAM) that is not used for display can be used as general data RAM. So whatever you send on the DDRAM is actually displayed on the LCD. For LCDs like 1x16, only 16 characters are visible, so whatever you write after 16 chars is written in DDRAM but is not visible to the user. Figures below will show you the DDRAM addresses of 1 Line, 2 Line and 4 Line LCDs.

00	01	02	03	04	05	06	07		32	33	34	35	36	37	38	39	← Character position (dec.)
00	01	02	03	04	05	06	07	••••••	20	21	22	23	24	25	26	27	← Row0 DDRAM address (hex)

Figure 3a. DDRAM Address for 1 Line LCD

00	01	02	03	04	05	06	07		32	33	34	35	36	37	38	39	← Character position (dec.)
00	01	02	03	04	05	06	07	•••••	20	21	22	23	24	25	26	27	← Row0 DDRAM address (hex)
40	41	42	43	44	45	46	47	•••••	60	61	62	63	64	65	66	67	← Row1 DDRAM address (hex)

Figure 3b. DDRAM Address for 2 Line LCD

00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	← Character position (dec.)
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	10	11	12	13	← Row0 DDRAM address (hex)
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F	50	51	52	53	← Row1 DDRAM address (hex)
14	15	16	17	18	19	1A	1B	1C	1D	1E	1F	20	21	22	23	24	25	26	27	← Row2 DDRAM address (hex)
54	55	56	57	58	59	5A	5B	5C	5D	5E	5F	60	61	62	63	64	65	66	67	← Row3 DDRAM address (hex)

Figure 3c. DDRAM Address for 4 Line LCD

Irish Interdisciplinary Journal of Science & Research (IIJSR)
Volume 7, Issue 2, Pages 16-27, April-June 2023

3. Proposed System

In this proposed system we utilize the solar energy from solar panels to automatically pump water from bore well directly into a ground level storage tank depending on the intensity of sunlight. While conventional methods include pumping of water from bore well into a well and from this well onto field using another pump, our system uses only a single stage energy consumption wherein the water is pumped into a ground level tank from which a simple valve mechanism controls the flow of water into the field. This saves substantial amount of energy and efficient use of renewable energy. A valve is controlled using intelligent algorithm in which it regulates the flow of water into the field depending upon the moisture requirement of the land. In this system we use a soil moisture sensor that detects the amount of moisture present in the soil and depending upon the requirement of level of moisture content required for the crop the water flow is regulated thus, conserving the water by avoiding over flooding of crops. Proposed irrigation system mainly consists of two modules- Solar pumping module and automatic irrigation module. In solar pumping module a solar panel of required specification is mounted near the pump set.

3.1. Project Design Hardware Components

The design of the solar powered smart irrigation system has the following components:

ARDUINO UNO

The main controller of the unit that is an open source platform for any development environment. It is microcontroller board based on 8-bit ATmega328P microcontroller. It consists of 14 digital input/output pins, 6 analog input pins, USB connection, power jack and reset button. The system has also components that includes crystal oscillator, voltage regulator and serial communication. The Arduino Uno can be programmed through an Arduino software using Wire library that can simply the use of I2C and SPI communication.

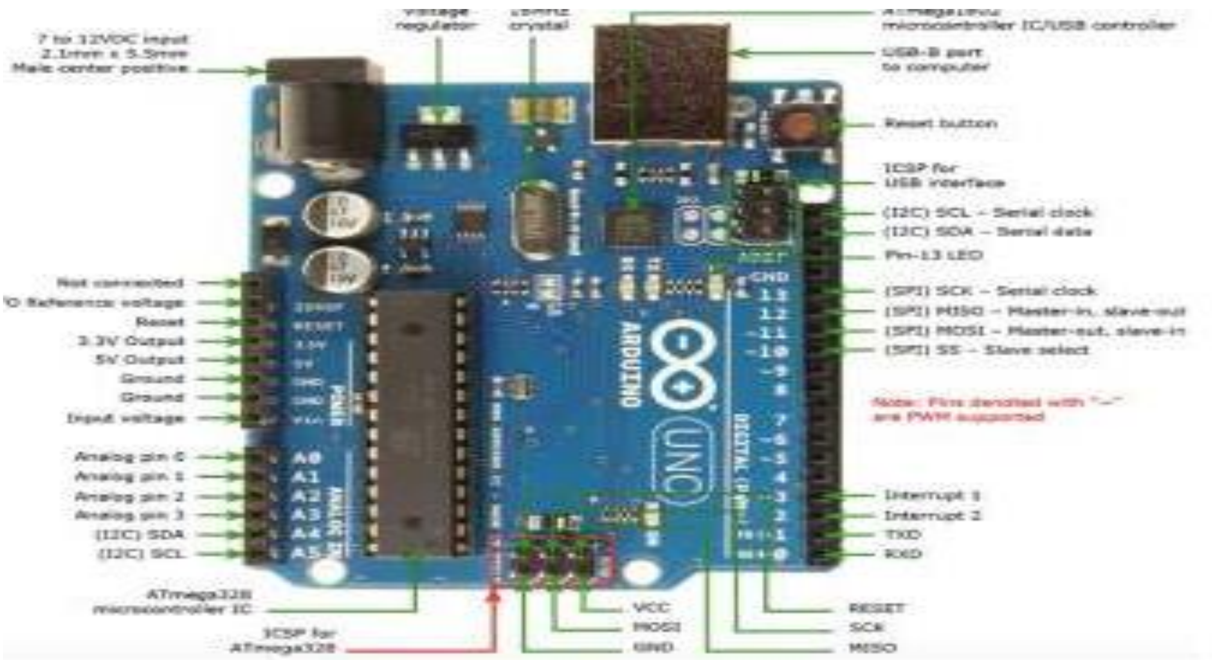


Figure 4. ARDUINO UNO Pinout Diagram

SOLAR PANEL

Photovoltaic arrays generates electricity from solar energy. The 12V solar panel is in accordance with IEC61215:1993 standards, using low iron tempered glass and EVA film with TPT back sheet to encapsulated cells [10,11].

Figure 5. Solar Panel

12V Battery

The main power supply of the system which is interconnected with solar charge controller and solar panel. If electricity is not generated to the solar panel as lack of sunlight, the supply power to the system comes from the battery. The solar panel can also charge the battery in the event of excessive power supply.

Figure 6. 12V Battery

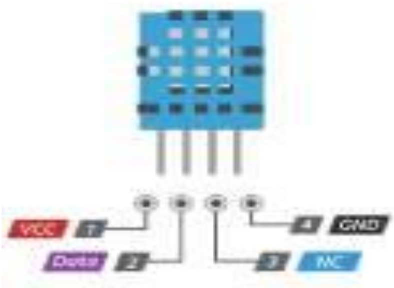
Relay Module

The system consists of two relays: 1) the 5V 4-channel relay interface board able to control the water pumps for the plants. 2). The 5V 1-channel relay for the water tank. Both relays is controlled directly by microcontroller.

Figure 7. Relay Module

DHT11 Temperature and Humidity Sensor

It is an 8-bit microcontroller to output the values of temperature and humidity. The sensor has NTC (Negative Temperature Coefficient) to measure from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. The sensor module is already embedded with resistor to interface with the microcontroller.



	DHT11
Operating Voltage	3 to 5V
Max Operating Current	2.5mA max
Humidity Range	20-80% / 5%
Temperature Range	0-50°C / ± 2°C
Sampling Rate	1 Hz (reading every second)
Body size	15.5mm x 12mm x 5.5mm
Advantage	Ultra low cost

Figure 8. DHT11 Technical Specifications

ESP8266 WIFI Module

This module is popular for its application on Internet of Things. The operating voltage for this module is 3.6V. It is a self-contained SOC that integrates with TCP/IP protocol that can communicate with the microcontroller to WiFi network.

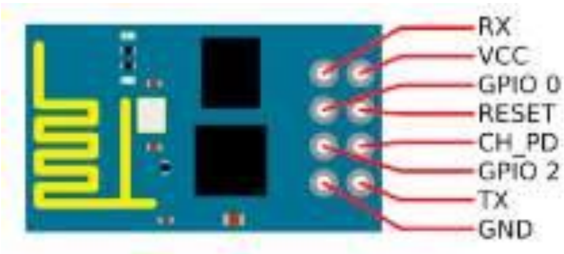


Figure 9. ESP8266 Module Pinout Diagram

Water Pump

The system consists of two pumps: 1) for the water storage tank 2) for the watering of plants in which the water takes from the storage tank and output it through the valves.

Figure 10. Water Pump

4. Project Implementation

The Arduino Uno is the main component of the solar powered smart irrigation system and is photovoltaic cells and battery that serves as the main power supply. Once the supply is connected, the microcontroller system will initialize all the connected device including the sensors, relays, the water pump and the wireless module.

Once the parameters are collected from the temperature and humidity sensor, soil moisture sensor and the tank storage capacity level, the data is sent wirelessly and display on the mobile application interface. The system has a DHT11 sensor which measures the climate condition on the area such as the temperature and humidity. Once the soil moisture content is determined by the soil moisture sensor, the controller will initiate the process in irrigating the plants. Threshold limit of 30%-55% represent the set moisture levels for the soil. If the read data is not within its range, such as the soil moisture content is read at 20%, the microcontroller with initiate to trigger the relays to activate the valves and switch ON the pump. In this way, the valves are open to water the plants since it indicates a low soil moisture content. The valves are switch ON until the desired moisture content is reached. When the moisture content is within the threshold limit, the microcontroller will signal to the relay to stop for the valves to switch OFF. The acquired data is displayed on the mobile application with indicators of the valves if it is on open or close state.

5. Results and Discussions

one of the various problems faced by farmers in their day to day farming activities is the constant need to watch over irrigation. Many times, the farmer must travel several kilometres to reach their fields and irrigation pumps. Hence, a huge amount of time and effort is expended daily in a farmer's life to irrigate the field when this time could be made use by the farmer at other farms such as animal husbandries which requires much more continuous observation and care. Through this paper, a project is proposed where a system is created to completely automate the process of irrigation such that none to minimal human intervention is required. The aim is to set up a wireless sensor network in the field which will collect data about the moisture in the soil and send information to start the water pump if the level goes below the threshold.

The prototype manages to start the moment with less to no human intervention the moment power is supplied. As soon as the system starts, the moisture sensor at the first index lights up which indicates that, through the combinational logic circuit, power has been supplied to this moisture sensor and it is in measuring mode. In this manner, all the sensors in a single row get the moisture level and sequentially send it to the primary NodeMCU when the power is with them. While testing the prototype, this was observed on the computer screen. And, thereafter, as per the value of moisture in that part of the field and the threshold decided, the corresponding part of the field was watered or skipped if the respective value is below or above the threshold. The secondary Node MCU along with the combinational logic circuit was able to water the field by running the motor and pump as well as opening the valve of solenoid valves of that particular part of the field where water supply is required. After circuiting the entire field once, the Node MCU switched to Deep-sleep mode and therefore conserving the power.

Figure 11. Solar Charge

The components installed are in good working condition and meet the desired requirements of the system. Another module displayed is the Solar Charge controller. Also, the DHT11 sensor which measures the temperature and humidity where the prototype is placed in an area.

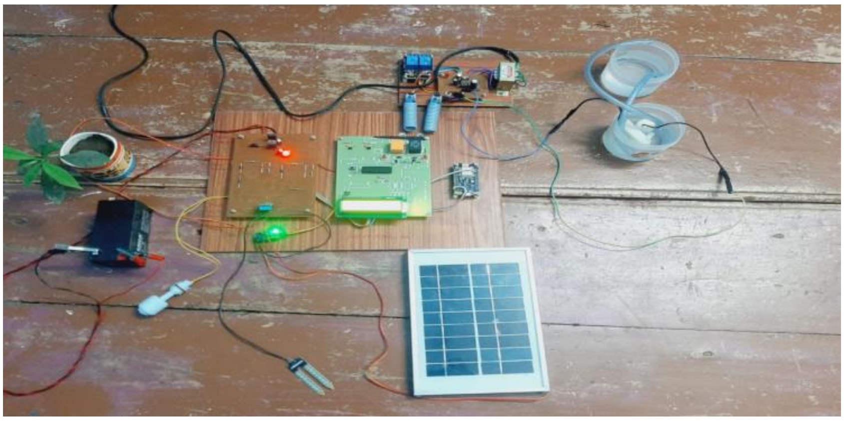


Figure 12. The Main Board

Figure below shows all the components of the system including the main board, pump, water hose, relays and valves.

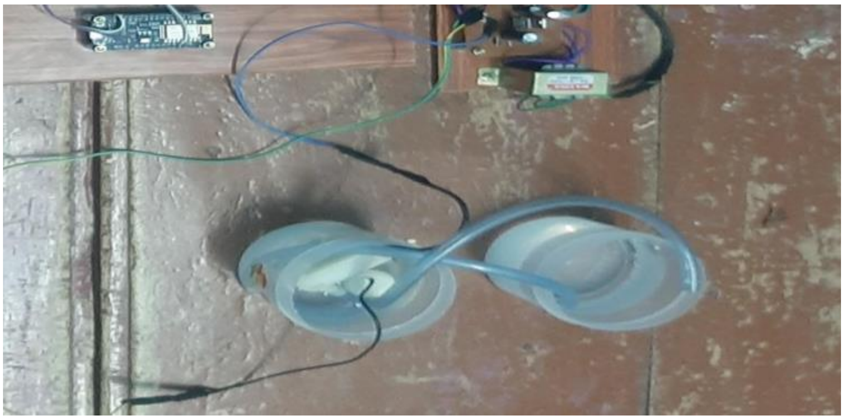


Figure 13. Water tank

Figure 13 represents the water tank storage for the irrigation system. The ultrasonic sensor is put on the top part of the container for more stabilization and to avoid contact with water.

Figure 14. Solar powered smart irrigation system

Figure 14 represents the main page of the mobile application graphical user interface. The software is available for both Google play for Android devices and App Store for IOS devices. The interface displays three main pages consists of Main, Moisture Level and Water Level. The main page displays the temperature and humidity sensor values.

Figure 15. Water Level Sensor

Analysis of System Data

The figure shows the water level sensor which indicates the reading at 93%. The water pump is OFF since it reaches the desired level set at the microcontroller. The maximum value is set to 90% hence, it is in close state and stopped filling the tank.

Soil Moisture Sensor

The figure below represents the three states of the soil moisture sensor. The desired limit for the moisture sensor is between 30-55% that indicates the moisture level is normal. Below 30%, the sensor indicates that the moisture level is low which means it needs to water the plants. Above 55%, moisture level state is high which does not need watering of plants. At Figure, it indicates that the sensor 1 is at 44% which shows that the moisture content is within the desired level, hence the pump is on CLOSE state. While sensors 2 and 3 indicates 0% that is below the limit, which turning ON the pump to start the watering process.

Figure 16. Soil Moisture Sensor 1

Figure 17. Soil Moisture Sensor 2

Figure 18. Soil Moisture Sensor 3

The figure represents the moisture sensor at 0% state which may indicate a severe dryness of soil content that causes the weather conditions in an area. In this state, the pumps are all turned ON until it reaches the desired level. Checking of the circuit and soil should be done manually at this time in cases of defective or short-circuited components.

6. Conclusions

This report describes automated irrigation system using IOT. Internet on things and cloud computing collectively system that control agriculture sector effectively. This system will sense all the environmental parameters and send the data to the user via cloud. User will take controlling action according to that this will be done by using actuator. This asset allows the farmer to improve the cultivation in a way the plant need. It leads to higher crop yield, prolonged production period, better quality and less use of protective chemicals.

The application of agriculture networking technology is need of the modern agricultural development, but also an important symbol of the future level of agricultural development; it will be the future direction of agricultural development. After building the agricultural water irrigation system hardware and analyzing and researching the network hierarchy features, functionality and the corresponding software architecture of precision agriculture water irrigation systems, actually applying the internet of things to the highly effective and safe agricultural production has a significant impact on ensuring the efficient use of water resources as well as ensuring the efficiency and stability of the agricultural production. With more advancement in the field of IoT expected in the coming years, these systems can be more efficient, much faster and less costlier. In the Future, this system can be made as an intelligent system, where in the system predicts user actions, rainfall pattern, time to harvest, animal intruder in the field and communicating the information through advanced technology like IoMT can be implemented so that agricultural system can be made independent of human operation and in turn quality and huge quantity yield can be obtained.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The author declares no competing financial, professional, or personal interests.

Consent for publication

The author declares that he/she consented to the publication of this research work.

References

[1] Rajalakshmi P., Devi Mahalakshmi S. (2016). IOT Based Crop-Field Monitoring And Irrigation Automation. 10th International conference on Intelligent systems and control (ISCO), 7–8 January 2016.

[2] V. Mohan & S. Senthilkumar (2022). IoT based fault identification in solar photovoltaic systems using an extreme learning machine technique. Journal of Intelligent & Fuzzy Systems, 43(3): 3087–3100.

[3] S. Senthilkumar, N. Prathap, T. Senthilkumar, V. Parthasaradi, D. Devarajan (2023). Energy Saving Solar Powered LED Street Lights with Automatic Intensity Control. Iconic Research And Eng. Journals, 6(10): 1–4.

[4] K.A. Patil and N.R. Kale (2016). A Model For Smart Agriculture Using IOT. 2016 International Conference on Global Trends in signal Processing, Information Computing and Communication.

[5] S. Senthilkumar, V. Mohan, G. Krithiga (2023). Brief review on solar photovoltaic parameter estimation of single and double diode model using evolutionary algorithms. International Journal of Engineering Technologies and Management Research, 10(1): 64–78. doi: https://doi.org/10.29121/ijetmr.v10.i1.2023.1291.

[6] N. Suma, Sandra Rhea Samson, S. Saranya, G. Shanmugapriya, R. Subhashri (2017). IOT Based Smart Agriculture Monitoring System. In 2017 International Journal on Recent and Innovation Trends in Computing and Communication.

[7] S. Senthilkumar, V. Mohan, T. Senthil Kumar, G. Chitrakala, L. Ramachandran & D. Devarajan (2022). Solar Powered Pesticide Sprayer with Mobile Charger and LED Light. International Journal of Innovative Science and Research Technology, 7(4): 205–210.

[8] Mahammad Shareef Mekala, Viswanathan P. (2017). A Survey: Smart agriculture IoT with cloud Computing. ISBN: 978-1-5386-1716-8/17/$31.00 ©2017 IEEE.

[9] D. Nathangashree, L. Ramachandran, S. Senthilkumar & R. Lakshmirekha (2016). PLC based smart monitoring system for photovoltaic panel using GSM technology. International Journal of Advanced Research in Electronics and Communication Engineering, 5(2): 251–255.

[10] S. Senthilkumar, L. Ramachandran, R. S. Aarthi (2014). Pick and place of Robotic Vehicle by using an Arm based Solar tracking system. International Journal of Advanced Engineering Research and Science, 1(7): 39–43.

[11] Prathibha S.R., Anupama Hongal, Jyothi M.P. (2017). IoT based monitoring system in smart agriculture. In 2017 International Conference on Recent Advances in Electronics and Communication Technology.